REPORT OF THE QUALITY MANAGEMENT WORK GROUP

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submitted to

The Activities Integration Committee

of the

Upper Great Lakes Connecting Channels Study Program

EXECUTIVE SUMMARY

This report describes the various initiatives of the Quality Management Work Group in support of the Upper Great Lakes Connecting Channels Study. They include:

- development of a Quality Management Strategy
- development of guidelines for preparing Combined Work-QA Project Plans
- provision for review of Project Plans
- provision of a series of interlaboratory Performance Evaluations (round robins)
- participation in the review of final reports relative to QA documentation

Each section of the following report addresses for each of these initiatives, some background discussion, the approach taken, achievements, problems encountered and other findings, and recommendations for further project QA improvements in future inter-agency studies of this type.

There is a real need for agencies to recognize the importance of QA-related documentation, and to be more prepared for external scrutiny in the future.

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INTRODUCTION

Background

The Quality Management Work Group (QMWG) was formed in the early planning phases of the Upper Great Lakes Connecting Channels Study (UGLCCS), when it was recognized that the success of the Study might well depend on the extent to which quality was built into all activities. The multiplicity of agencies and jurisdictions participating, and the wide variety of analytical, field, and data management procedures likely to be employed, could provide many opportunities for differences to develop between data sources. These could adversely affect the interpretation of results and the validity of Study findings and recommendations.

Despite the presumed existence of quality control (QC) and quality assurance (QA) practices within the various agencies, experience in previous international programs had made it clear that data quality and compatibility could be assured only by a positive quality management process. This process would require participants to document the quality control and quality assurance practices they would implement within their individual projects. It would then provide for a verification that the practices were carried out and that the quality of their data could be demonstrated.

Role

The specific role of the QMWG was:

i) to advise the Activity Integration Commmittee (AIC) on acceptable project quality management practices,

ii) and to advise the other UGLCCS Work Groups of the implications of the presence or absence of documented quality assurance and quality control activities, and

iii) on the possible implications of field and analytical procedures chosen by the Project Officers in pursuit of UGLCCS goals.

In brief, the role of the QMWG was to ensure top-down rather than bottom-up assignment of quality assurance responsibilities, and to encourage the documentation of project data quality, including the identification and resolution of field or analytical problems. This was to be achieved within the limitation that individual agencies retained the authority to define their own protocols and procedures. It was hoped that they could be encouraged to come to a concensus on methodologies which might impact on inter-project data compatibility.

Terms of Reference

In consultation with the Management Committee (MC) and the Activities Integration Committee (AIC), the following Terms of Reference were determined:

1. Establish and verify the existence of a quality management system for the UGLCSS.
2. Review and evaluate the suitability and completeness of INDIVIDUAL QA project plans.
3. Recommend QA requirements in sampling, sample handling, analysis, management of project data and quality control data.
4. Compile, review, and report on the appropriateness of analytical and field protocols documentation in QA project plans, as they become available.
5. Provide guidance to the other Work Groups in the analysis and use of historical data as required by the AIC.
6. Receive and review periodic QA reports from the individual Work Groups.
7. Participate in the review of draft project reports with respect to QA issues.

QMWG Membership

The membership of the QMWG was drawn from laboratory, field, project, quality assurance, and data management personnel. All contributed from their experience in the quality assurance aspects of their particular field. The strength of the work group lay in the diverse experience of each of its individual members, which, brought together, provided a unique basis for quality management. a list of individual participants is given in Appendix I.

THE QUALITY MANAGEMENT STRATEGY

Background

Quality Management (QM) provides a basis for ensuring that the quality objectives of an organization are met and that the level of quality achieved is documented. It defines responsibilities, and assigns duties. It establishes accountability, and ensures implementation by some form of audit process. The assessment and management of quality presumes the prior existence of documented procedures, operated under specified and controlled conditions.

Quality is not an absolute. It is measured in terms of need. An important facet of the project planning process is to identify the level of quality that will be required to support the decisions to be made.

Subsequent elements in the quality planning and management process would;

- assess the state of the art of the alternative technical processes available, and expertise of the personnel using them,
- verify that all procedures were properly documented, and that their relative impact on the quality of data was determined,
- assign control activity over those processes deemed most significant to maintain data quality,
- establish mechnisms for documenting that control was maintained and that appropriate action was taken if control was lost,

- establish mechanisms for independent audit of the level of quality achieved,
- verify that necessary records were maintained, and evaluate the data quality information available in support of the decisions to be made.

It must be recognized that each agency has its own criteria for determining suitable field and laboratory procedures, and that in most cases these are chosen to meet their specific mandate. Within the time available for the UGLCCS, it was not possible, and probably not advisable to institute method changes to achieve a standard procedure across participants.

The most that could be achieved would be to,

a) encourage good project planning, including all necessary quality assurance activity,
b) encourage documentation of methods,
c) initiate a limited number of round-robins using such standards as were readily available to evaluate the accuracy of participating labs.

In support of the latter activity, a member of the Work Group was ultimately able to prepare a list of the participating laboratories, the sample matrices and the tests being performed.

Approach

The sheer diversity of the environmental studies being undertaken, the numbers of jurisdictions, agencies and laboratories involved, and the differences in project objectives, underscored the effort required to achieve some degree of concensus about quality requirements and associated documentation. Hence, the priority tasks for the QMWG were determined to be;

a) prepare a quality management plan for approval and adoption by the UGLCCS Management Committee and the Activity Integration Committee.
b) initiate liaison with the other Work Groups via their chairperson or other designated Quality Coordinator.
c) define guidelines for the preparation of work-QA project plans.
d) develop criteria for acceptance of project plans and define the approval process.
e) develop a series of round-robin studies to evaluate the inter-laboratory comparability of analytical measurements.
f) encourage project officers to arrange for inter-lab exchange of split samples to demonstrate the ongoing comparability of data for related projects.
g) encourage project officers to include statements of their program design to allow for a statistical review.

QM Activities

The QMWG prepared documents outlining the responsibilities of the MC, AIC, and the other UGLCCS Work Groups to ensure that individual project officers responded to the need for project planning and documentation prior to implementing field activity. (see Table I)

Throughout the Study the QMWG maintained close contact with the Management Committee and the Activity Integration Committee. A quality management strategy was defined. A guideline was prepared for use in project planning. Project plans submitted to the other Work Groups by the principal investigators were reviewed by the QMWG in terms of their intended QA activity and QC procedures. Funding for QMWG activities was obtained, and a series of inter-laboratory performance evaluation studies was implemented. Progress reports were submitted, and areas of QMWG concern were identified.

It was immediately clear that there was some confusion about the role of the QMWG and the need for Project QA. Some felt that the QMWG members would function as Project QA Officers.

Ultimately it was resolved that the QMWG would indeed review and evaluate the level of QA-QC being planned into the projects. It would not be in a position to audit the actual procedures being followed, the completeness of the records being kept, or the level of quality achieved. Responsibility for these tasks properly resides within the Quality Management structure of the respective agencies.

TABLE 1

List of QMWG Reports

1) Role and Resource Requirements for a QA/QC Program for the UGLCCS
   -submitted to Activity Integration Committee
   First draft . . . . . .January 16, 1985
   Revised draft . . . . . .February 5, 1985
2) Work/QA Project Plan Guidance
   - submitted to Management Committee
   First draft . . . . . Dec., 1984
   Revision . . . . . Feb., 1985
3) QA Considerations
   - submitted to chairmen AIC, MC and Work Groups . . . June 3, 1985
4) Progress Report no.1
   - submitted to chairmen AIC, MC and WG's . . . . . Dec., 1985
5) Progress Report no.2
   - submitted to chairmen AIC, MC and WG's . . . . . .Mar. 21, 1986
6) Concerns of the QMWG
   - submitted to Mr. Greg Woodsworth
     and QMWG members . . . . . .Mar. 21, 1986
7) Specific Concerns of the QMWG
   - submitted to chairmen AIC, MC and QMWG . . . . . June 6, 1986
8) Progress Report no.3
   - submitted to chairmen AIC, MC and WG's . . . . . Sept., 1986
9) Progress Report no.4
   - submitted to chairmen AIC, MC and WG's . . . . . .Feb. 10, 1987

The actual recommendation of the Work Group was that each project identify a Project QA Officer to perform these tasks.

There was a general feeling among the principal investigators that project and field QA needs would be adequately covered by laboratory oriented QA-QC. The requirement to present a work-QA Project Plan clarified the need for project QA.

It was recommended that each UGLCCS Work Group screen the project plans being brought to it, in terms of its objectives relative to that Work Group's needs. The QMWG would then review the project with respect to those factors which might affect the overall quality of the project and its compatibility with other related projects.

Findings

The QMWG feels that it did achieve the primary objective of increasing the level of QA-QC awareness among Project Officers, and as a result there was an increased documentation of procedures and data quality beyond what has been observed previously.

The limited time frame of the study, the ongoing status of many of the projects, limited awareness of the quality management needs and their relationships to project, field and laboratory QA-QC all preveted the QMWG from acting to review and verify specific QA-QC details on the project by project basis.

There is a significant need for all agencies to:

- externalize the results and effectiveness of the QA-QC programs,

- promote the use of combined work-QA project plans,
- expose themselves to external review.

The QMWG did not have the resources to audit the actual level of QA-QC applied during the field, project and laboratory activities. An independant audit with suitable standards and suitable resources is essential to verify adherence to all QA protocols in future inter-agency studies.

GUIDELINES FOR PREPARATION OF WORK-QA PROJECT PLANS

Background to Project Planning Guidelines

One of the QMWG terms of reference raised the question of compatibility of field and laboratory procedures across the UGLCCS. It was suspected from the start that many of the field techniques employed for sampling and sample handling were relatively untested, especially for the organic constituents. There was concern about the validity and compatibility of alternative procedures. There were questions about the analytical procedures that might be employed, in terms of their ability to identify and quantify the many chemical constituents of interest in water, sediment, biota and other samples. Of course these issues were recognized by the other Work Groups, and were most certainly the topic of much discussion

Some difficulty was anticipated because the different jurisdictions employed a variety of control practices to a greater or lesser degree. There was concern that field and laboratory methods

might not include the quality control and quality assurance protocols needed to verify proper application, and to document the level of quality achieved for UGLCCS.

In the past, the impact of ongoing QC activity in all of these areas had been limited by the absence of a "top-down" management system to define responsibilities and ensure adequate documentation. A USEPA report, "Guidance for Preparation of Combined Work Quality Assurance Project Plans for Water Monitoring" (OWRS-QA1 May 1983), provided the basis for initiating a verifiable QA process.

Approach to Project Planning and Documentation

An UGLCCS Work-QA Project Plan guidance document was prepared by the QMWG (Appendix II), based on the USEPA document (OWRS QA-1). It was approved by the MC in February 1985, and distributed through the AIC to the other Work Group chair-persons for circulation to and action by all principal investigators. This format was to be used in describing the way in which each project would be managed to define both work and QA-QC activities. The Guideline was supplemented in June 1985 by a short list of Quality Assurance Considerations.

The topics covered in the Guideline included the following. Each topic addressed in detail the type of information to be provided, and examples were attached.

- Project Title Page (and Responsibilities)
- Objective and Scope Statement

- Data Usage
- Sampling Design and Rationale
- Sampling Parameters and Frequency of Collection
- Parameter Table (tests, sample matrix, and method reference)
- Analytical Method Documentation
- Schedule of Tasks and Products
- Project Organization and Responsibility
- Data Quality Requirements and Assessments
- Sampling Procedures
- Sample Tracking Procedures
- Calibration Procedures and Preventive Maintenance
- Documentation, Data Reduction and Reporting
- Data Validation
- Performance and System Audits
- Corrective Action
- Reports.

Two tables were included in Appendix II to facilitate comparison of project QA needs versus the analytical capabilities.

Findings

The requirement for Work-QA Project Plans emphasized the importance of pre-implementation evaluation of topics such as site selection, sampling protocols, field and lab QC, field and lab sample

handling and preservation and storage, analytical preparation and measurement procedures, reporting of results and detection limits.

The ability of the principal investigators to respond to this QM requirement was hindered to a large extent by the novelty of this approach, and the difficulties encountered in obtaining the necessary procedural documentation from field and laboratory personnel.

The QMWG noted a definite tendency for Project Officers at the outset of the UGLCCS, to depend solely on the analytical precision and accuracy estimates for the analytical methods (ie. lab QC), and to ignore or downplay the effect of sampling and sample handling.

The need to prepare Work-QA Project Plans had a positive impact on the planning and documentation of the projects. The time frame available did not permit the resolution of any problems that might have been identified during the planning stage. This may have some effect on the future usefulness of data collected during UGLCCS, as techological advances are made on the basis of procedural problems identified during the Study.

REVIEW OF UGLCCS WORK-QA PROJECT PLANS

Background

UGLCCS required input from many special studies to address gaps in current understanding of environmental processes in the Connecting Channels and surrounding geographic areas. However, the

bulk of the data would probably come from ongoing agency programs addressing regulatory or surveillance type needs.

The "top-down" approach to project quality management required a review of the Project Plans by both the 'task' oriented Work Groups, for whom the project was being developed, and by the QMWG. This review would provide the Management Committee with some assurance of compatibility among project goals, laboratory and field protocols, and data interpretation and modelling concepts.

The QMWG was to evaluate the ability of the proposed projects to produce data of known and acceptable quality, this review was the only opportunity for the QMWG to authenticate adherence by the principal investigators to the QA-QC needs of UGLCCS.

Project officers were expected to define their project goals and objectives and to specify the data quality requirements necessary to success. They were to contact the field and laboratory persons upon whom their project depended, to obtain the necessary procedural documentation. They would then identify and resolve any discrepancies between project objectives and capabilities.

They would also identify sampling sites, prepare work schedules, add any needed project QA samples (eg. duplicates, controls, inter-laboratory and inter-project split samples, etc.). They were to present their data management needs and intentions (eg. data reporting protocols, data storage-retrieval, modelling and statistical needs, etc.).

The Work-QA Project Plan was to be forwarded to the appropriate UGLCCS Work Group for discussion and general acceptance. It would then be sent to the QMWG for review of QA-QC and data management factors. Where problems were identified, the principal investigator was expected to resolve these issues and resubmit the revised plan, or at least document the adjustment being made.

Project Plan Review Findings

The sheer magnitude of the Study required intensive effort on the part of all Work Group chair-persons to keep projects on track. Ultimately, some projects were implemented without adequate prior QA review.

Project plans were received from the Work Groups as follows:

Biota	12
Sediment	10
Point Source	3
Water	2
Non-point Source	3

The Work-QA Project Plans were distributed as received for review by teams of one or two QMWG members based on their expertise in field, laboratory, QA, sampling design and related statistical factors.

This QA exercise was new to most participants. Project plans tended to follow the guidelines but were not necessarily

complete in defining or justifying their methodology, data quality needs, or relationship to methodologies used by other related projects.

There was a definite problem for many in providing detailed up-to-date descriptions of their field, lab, or QA-QC procedures. This is not to suggest that there were not defined procedures, or that there were not appropriate QA-QC activities in place, but simply that the necessary documentation was not always readily available, and therefore the issue remains unresolved.

Some provided excellent documentation in one or more areas, but there was not always a clear link between project needs and the specific technology used.

Not all plans were evaluated for their sampling design or other statistical aspects because some projects were essentially exploratory or were already in progress or even completed. Due to prior committments, some statistical consultants were unable to review the project plans. The MC-AIC were advised of this.

It is the concensus of the QMWG that, for the most part, the Biota Work Group prepared excellent plans in a timely manner. This facilitiated a timely review by the QMWG members concerned, and appropriate interaction. An integrated report of the QA review for these projects was prepared, and it was recommended that the other QA reviews follow a similar format.

While the specific findings of the QA review are detailed in the individual and integrated reports, some general comments that apply to many of the Work-QA project plans are noted below.

There was resistance on the part of some Work Groups concerning the format/need/detail requested in the Project Plans. Many of the project plans were presented too late for the QMWG review to have any real impact. There was a great deal of confusion as to some of the material being provided and its relevence to UGLCCS. These factors had a negative effect on the QMWG review process.

Many of the plans lacked significant portions of the documentation requested in the Guideline. Others provided in-house QA documents, procedures, etc., but did not present them in the context of the specific UGLCCS activity being undertaken. This caused problems in comparing the Plan as described against the Guidelines.

Laboratory methods are generally not described in sufficient detail to permit a QA evaluation. They often lack performance or inter-method comparison statements. In some cases project plans referenced outdated or unavailable method manuals, or provided no procedural details.

The areas of expertise resident in the individual members of the QMWG, lack of familiarity with specific laboratory or field or statistical practices, etc., and the time available to them to carry out the review, all affected the thoroughness of the review process.

There is a real need for agencies to recognize the importance of QA-related documentation, and to be more prepared for external scrutiny in the future.

INTERLABORATORY PERFORMANCE EVALUATIONS

Background

Despite the possible impact of field activities, sample handling/preservation, delays initiating analysis, sample matrix effects on the analytical process, etc., there is no question that the analytical measurement is critical to the validity of project data.

Traditionally, the single most serious source of variation between results from different laboratories is control of standards and the calibration process. For this reason the QMWG agreed to place most emphasis on the distribution of a series of check standards covering all of the UGLCCS parameters for which checks were available.

Approach

The QMWG recommended that interlaboratory performance evaluation quality control studies should be designed and carried out at least three times with test materials containing all constituents at low, medium and high concentrations. Such studies would be presented and evaluated before, during and at the close of all analytical and field related activities. These studies carried out in conjunction with a quality management strategy and in concert with an interagency field split-sampling program would allow management full control and assurance of data quality for the UGLCCS program. It was

evident this comprehensive program could not be issued in a timely manner (see Appendix III).

The reduced program involved less frequent studies, use of only standard solutions, surrogate spikes and a limited number of natural reference materials.

Achievements

The samples for the thirteen studies listed in Table II were prepared and distributed. The participants in these studies are tabulated in Table III. The constituents for which analyses were requested involved 36 inorganic and 50 organic parameters. The schedule, substrates and parameters in these studies are summarized in Table IV. Three reports for each interlaboratory study were (or will be) generated.

a) a raw data summary to the participants (for verification),

b) a final data summary when the study was closed,

c) and a final laboratory performance evaluation report.

In addition, 3 status reports entitled "Brief overall data review of interlaboratory PE studies" were prepared to advise MC and AIC chairmen on extreme results. Extreme results were those results that deviated significantly from target values. The advance advisory report "Brief overall data review of Interlaboratory Performance Assessment Studies" Part I to Part III from the QMWG to the MC/AIC was viewed as constructive for the UGLCCS management to respond and

TABLE II
QC Study Parameters
Interlaboratory Performance Evaluation of QC Studies
UGLCCS

Study	Test Samples	Parameters	Substrate
QM-1	4 ampuls 4 ampuls 4 ampuls	Aroclors O.C. Insecticides* Chlorinated Hydrocarbons**	std solutions std solutions std solutions
QM-2	4 ampuls	16 PAHs	std solutions
QM-3	5 sediments	10 Metals	sediment CRM or RM
QM-4	4 waters	23 Major Ions & Nutrients	water CRM
QM-5	4 waters	7 Metals	water CRM
QM-6	4 sediments 2 ampuls	Chlorinated Hydrocarbons** Chlorinated Hydrocarbons**	sediment CRM or RM std solutions
QM-7	2 ampuls 2 ampuls 4 ampuls	Aroclors Chlorinated Hydrocarbons** Aroclors & Chlorinated Hydrocarbons**	std solutions std solutions spiking solutions & natural water
QM-8	4 ampuls 4 ampuls	Chlorinated Insecticides* Chlorinated Insecticides*	std solution spiking solutions & natural water
QM-9	4 waters	Mercury	water RM
QM-10	2 ampuls 4 ampuls	16 PAHs 15 PAHs	std solutions spiking solutions & natural water
QM-11	4 waters	Cyanide	water RM
QM-12	4 waters	Total Phenol	water RM
QM-13	2 ampuls 2 oils 2 tissues	5 Chlorophenols	std solutions fish oils fish tissues

* HCB, (alpha, gamma) BHC' Mirex, pp'-DDE' pp'-DDD, pp'-DDT, heptachlor epoxide, dieldrin, (alpha, gamma) Chlordane, oxychlordane
(1,4;1,3;1,2) dichlorobenzene
(1,3,5;1,2,4;1,2,3) trichlorobenzene
(1,2,4,5;1,2,3,4) tetrachlorobenzene
pentachlorobenzene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, octachlorostyrene

TABLE III
Participants in the UGLCCS Performance Evaluation Studies

U.S. Laboratories

The Bionetics Corporation, (U.S. Environmental Protection Agency - Great Lakes National Program Office), Chicago, Illinois, USA.
Clarkson University, (U.S. Environmental Protection Agency - Large Lakes Research Station, Gross Ile, Michigan), Potsdam, New York, USA.
Detroit Water and Sewerage Department - Analytical Laboratory, Detroit Michigan, USA.
Great Lakes Environmental Research Laboratory - National Oceanic and Atmospheric Administration, Ann Arbor, Michigan, USA.
Michigan Department of Public Health - Centre for Environmental Health Science - Epidemiological Studies Laboratory, Lansing, Michigan, USA.
Michigan Department of Natural Resources, Lansing, Michigan, USA.
Raytheon Service Corporation (U.S. Environmental Protection Agency - Large Lakes Research Station), Grosse Ile, Michigan, USA.
University of Michigan - Great Lakes Research Division, (U.S. Environmental Protection Agency - Great Lakes National Program Office and Great Lakes Environmental Research Laboratory - National Oceanic and Atmospheric Administration) Ann Arbor, Michigan, USA.
U.S. Army Corps of Engineers - Environmental Analysis Branch, Detroit, Michigan, USA.
U.S. Geological Survey - National Water Quality Laboratory, Arvada, Colorado, USA.

Canadian Laboratories

Barringer Magenta Limited, Rexdale, Ontario, Canada.
Beak Analytical Services, Mississauga, Ontario Canada.
Mann Testing Laboratories, Mississauga, Ontario, Canada
National Water Research Institute, Environmental Contaminants Division - Inorganics Section, Burlington, Ontario, Canada.
National Water Resarch Institute, Environmental Contaminants Division - Organics-Pathways Section, Burlington, Ontario, Canada.
National Water Resarch Institute - Environmental Contaminants Division - Organics-Properties Section, Burlington, Ontario, Canada.
Ontario Ministry of Environment, London, Ontario, Canada.
Ontario Ministry of Environment - Inorganic Trace Contaminants Waters Unit, Rexdale, Ontario, Canada.
Ontario Ministry of Environment - Trace Organics Section - Drinking Water, Rexdale, Ontario, Canada.
Ontario Ministry of Environment - Trace Organics Section - Sediment and Biota, Rexdale, Ontario, Canada.
Ontario Ministry of Environment - Trace Organics Section - Wastewater, Rexdale, Ontario, Canada.
Ontario Ministry of Environment - Water Quality Section, Rexdale, Ontario, Canada.
Ontario Ministry of Environment - Thunder Bay, Ontario, Canada.
Wastewater Technology Centre, (Conservation and Protection, Toronto), Burlington, Ontario, Canada.
National Water Quality Laboratory, Burlington, Ontario, Canada.
Zenon Environmental Inc., Burlington, Ontario, Canada.

INTERLABORATORY PERFORMANCE EVALUATION or QC STUDIES

UGLCCS

TABLE IV QC STUDY SCHEDULES

Study No.	No. of Questionnaires	No. of Participants	SEND OUT DATE Questionnaires	Samples	Reporting Deadline	No. of labs Reporting
QM-1	45	16	Dec 17/85	Jan 24/86	Mar 20/86 closed-July 4/86	9
QM-2	45	16	"	"	"	7
QM-3	45	15	"	"	"	10
QM-4	50	13	Jan 31/86	Feb 28/86	Apr 30/86 closed-Aug 8/86	10
QM-5	50	14	"	"	"	11
QM-6	50	12	"	"	"	7
QM-7	55	16	Feb 28/86	Mar 27/86	May 15/86 closed-Sept 30/86	12
QM-8	55	14	"	"	"	10
QM-9	55	12	"	"	"	11
QM-10	59	14	Apr 2/86	May 1/86	May 30/86 closed-Oct 10/86	9
QM-11	59	10	"	"	"	7
QM-12	59	10	"	"	"	7
QM-13	55	6	May 9/86	Jun 24/86	Aug 1/86 closed-Oct 17/86	2

implement the QA management strategy and to ensure that appropriate remedial action could be taken by WG chairmen and project leaders.

Findings

It is difficult to summarize the performance of laboratories in a few paragraphs because data quality varies with each parameter, matrix, laboratory and time. Furthermore, the acceptability of data for each laboratory depends on project objectives. In general the large service laboratories performed consistently better than the smaller service laboratories and research laboratories did not perform as well as the routine laboratories.

It is stressed that the QC samples sent out in the inter-laboratory PE studies for UGLCCS are generally easier to analyze than actual field samples because most of these study samples were standard solutions at reasonably high concentrations. It is also a recognized fact that many laboratories spent extra care and performed repetitive analysis when dealing with the QC samples. Therefore, unsatisfactory performance in these interlaboratory studies may indicate a poorer quality of data for real samples in routine analysis.

The impact of these interlaboratory studies is illustrated by a couple of examples. A large contract laboratory was identified as having severe analytical problems in several PE studies partly due to ineffective in-house QC. The laboratory took remedial actions.

The data quality for one type of parameters (PAH's) has drastically improved as reflected in the results of a later study (QM-10).

Interlaboratory PE (QC) studies were clearly constructive. We were informed on separate occasions by three research laboratories and one large routine laboratory that our interlaboratory PE studies induced them to re-examine instrumental calibration and the accuracy of the standards for chlorophenols, chloronbenzenes and PCBs. Consequently, they discovered they had poor in-house standards and improper calibration. Without these interlaboratory test samples, these laboratories would not be aware of their internal bias.

The timeliness of QMWG follow-up on the findings of these studies was significantly impaired by the slow response of some of the participating laboratories. The reporting deadlines were frequetly exceeded. The actual number of laboratories providing results for any given test parameter depended on whether their UGLCCS project required them to analyze for it. This meant that for some tests where severe scatter between laboratories was observed, it was not possible to decide whether this reflected poor control, or just the current state of the 'art'.

Many of the check samples were standards, and one would expect reasonably good recoveries and precision. In fact, for many of the organic tests, although a given lab frequently reported very similar results on the duplicate samples, the spread of results across labs was quite large. There is a definite need for an intensified

effort by the organic analysts for better control of standards, and the overall calibration and quantitation process.

UGLCCS QA BILL OF HEALTH

The QMWG, at the time of preparation of this report, has no way of determining whether QA/QC activities were performed, or what level of data quality was achieved. There were suggestions that the QMWG should receive and evaluate all QA/QC data. This is simply not practical. QA data evaluation is an integral component of the Project Officers data review and subsequent project report. It is critical in deciding the validity of any hypotheses being raised.

The presence or absence of quality statements in the individual project reports is not necessarily an indication of the quality of work. The credibility of conclusions drawn in reports are enhanced by the presence of quality statements.

An important facet of the QMWG's role is participation in the review of individual project reports. This may well be impossible given the timeframe available. It is certainly incumbent on the UGLCCS Work Groups to address the question of project data quality as they attempt to synthesize findings of quite diverse projects into a comprehensive evaluation of the state of the different geographic basins.

It is not possible at this time to provide a blanket statement as to the overall data quality of the UGLCCS. The QMWG

objective was to encourage and promote better documentation of QA/QC so that such decisions could be reached on a project by project basis.

APPENDICES

APPENDIX I

Membership of Quality Management Work Group

APPENDIX I

Membership of Quality Management Work Group

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APPENDIX II

UGLCCS Combined Work/QA Project Plan Guidance Document

Upper Great Lakes Connecting Channel Study

Quality Management Work Group

Work QA Project Plan Guidance

Title Page (With Project Officer, QA Officer and Agency/Division Director signatures, the exact format of this page will vary according to specific organizations and their designated responsible individuals.

1. Project Name

2. Date of Project Initiation

3. Project Officer

4. Person Assigned as Project QA Coordinator

5. Project Description

The purpose of the project description is to define the objectives (goals) of the project and describe how the project will be designed to obtain the information needed to accomplish the project goals. The project description should consist of the following:

A. Objective and Scope Statement

This section should consist of a comprehensive statement addressing the project's objective (purpose) and an overview of the project's scope

(activities). Background information pertaining to the project (i.e., reconnaissance information) should be included.

B. Data Usage

This section should consist of a comprehensive statement outlining the intended data usage. It is important to clearly indicate this usage so that suitable sampling, analytical and QA/QC protocols are selected. When applicable, secondary uses of the data should be identified. The following are examples of data uses:

Mass balance calculations

Identification of effects

Calibration and Verification

Identification of Problem Areas

Differentiation of Sources

Cause and Effect Correlations

C. Sampling Design and Rationale

This section should address the design of the overall sampling system, the specific locations of the sampling sites, and the justification for the

overall sampling work design. As discussed in Section II, data representativeness, comparability, and completeness should be considered an integral part of the sampling design. Other relevant factors which influence the design of the sampling work should also be considered and reflected in the plan (e.g., homogeneity of the system under investigation, accessibility of the sampling area, stream flow conditions, seiche fluctuation, weather conditions).

D. Sampling Parameters and Frequency of Collection

This section should discuss the types of information to be collected at the various sampling sites. This may be done in tabular form provided the following information is listed:

- sampling site location (e.g., latitude/longitude, River Mile Index, Depth);
- type of sample (e.g., grab sample, cross-sectional stream composite sample);
- sample matrix (e.g., stream surface water, river bottom sediment);
- parameters to be analyzed (e.g., copper, lead);
- sampling frequency; and
- total number of samples.

"Type of sample" should be only a brief description. A detailed description of the sample collection method will be addressed in Item 9.

E. Parameter Table (See Attachment 1)

This table should provide the following information for each parameter analyzed:

- sample matrix;

- analytical method reference; and

The analytical method reference must correspond to that specific procedure which is followed in the laboratory for the analysis of that parameter in that matrix.

F. Analytical Method Documentation

The method must be validated and documented in detail. The documented method must be made part of the project plan by incorporation into the laboratory's Standard Operating Procedures (SOPs) and by becoming an attachment to this quality assurance work plan. Performance data must accompany each analytical method.

6. Schedule of Tasks and Products (See Attachment 2)

The progress of the project from conception to implementation should be followed. It is necessary to plot each phase of the project contained in the project schedule, from initial request to final project report.

This includes:

- the date of the request which initiates the project;

- the date by which the project plan will be submitted to all interested parties (Work Groups and QMWG);

- the date by which comments on the plan are to be returned to the project officer;

- the date(s) of the field reconnaissance;

- the date(s) of the field sampling activities;

- the date(s) the samples will be submitted to the laboratory for analysis;

- the date(s) by which all analyses are to be completed and the data submitted to the project officer;

- the date(s) the data will be entered into STORET or other computerized systems;

- the date of the completion of the draft interim/final project report;*

- the date by which the reviewers' comments on the report(s) must be received;*

- the date for completion of the peer review process;* and

- the date for the issuance of the final project report.*

Each step in this process should be scheduled in an objective and realistic time frame to assure that adequate attention is devoted to the minimization of effort and the maximization of information.

7. Project Organization and Responsibility

In order for the study to proceed smoothly and yield valid and usable data, it is essential that all individuals are clearly identified and informed of their responsibilities. The Project Organization and Responsibility Section of the Work/QA Project Plan should, at a minimum, identify key individuals responsible for:

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*Optional as far as QMWG requirements are concerned.

- sampling operations

- sampling QC.

- laboratory analyses

- laboratory QC.

- data processing activities

- data processing QC.

- data quality review

- performance auditing

- systems auditing (on-site evaluations)

- overall QA

- overall project coordination

- data interpretation and reporting

It is often useful on a project to indicate how these individuals relate in the organization(s). An organizational chart is a convenient way of illustrating this.

For each key individual named, a brief sentence or two explaining that individual's responsibility should suffice. Telephone numbers should be listed with the key individuals in order to facilitate communications.

Where there are several different monitoring institutions or subcontractors involved, complete addresses should be provided.

8. Data Quality Requirements and Assessments (See Attachments 3, 4, and 5)

It is important in project planning that a cooperative effort be undertaken by the project officer, sampling, and analytical personnel to define what levels of quality shall be required for the data. These data quality requirements shall be based on a common understanding of the intended use of the data, the measurement process, and availability of resources. Once data quality requirements are clearly established, QC protocols shall be defined for measuring whether these requirements are being met during the study.

As a minimum, requirements should be specified for detection/quantitation limits (including standard deviation at lower end of operating range based on replicate analysis of samples), precision, and accuracy for all types of measurements, including method of calculation, where these are appropriate. A procedure for determining method detection limits is covered in "Methods for Organic Chemical Analysis for Municipal and Industrial Wastewater," EPA 600/4-82-057.

Customarily, laboratory personnel provide the project officer with method options covering a given parameter and type of sample. These options are accompanied by respective detection/quantitation limits and statements of precision and accuracy. Once the method options are selected, the detection/quantitation limit, precision, and accuracy requirements should be incorporated into the work/QA Project Plan. Along with each requirement, there should be a protocol for monitoring whether these requirements were met. For example, intralaboratory precision can be monitored by using replicate samples. Accuracy can be monitored with the use of field and method blanks, spikes, surrogate spikes, National Bureau of Standards' Standard Reference Materials (SRMs), EPA QA reference samples, etc.

Whenever possible, criteria should be set for the "total measurement." This could be accomplished, for example, with the use of field replicate samples.

Frequency of QC sample analysis and statistical reporting units shall be defined in the Work/QA Project Plan.

When discussing data quality requirements, consideration should also be given to data representativeness, comparability, and completeness.

- Representativeness is a quality characteristic. For most water monitoring studies, it should be considered a goal to be achieved rather than a characteristic which can be described in quantitative terms. An example of the need for representativeness is in the planning for the collection of surface water samples from a stream and the subsequent use

of the data for determining wasteload allocations. The question to be addressed is how the sample will be collected to ensure its relationship to the stream characteristics (i.e., the taking of grab samples in a restricted zone of the stream compared to a complete transect sampling).

- Comparability is also a quality characteristic which must be considered in study planning. Depending on the end use of data, comparability must be assured in the project in terms of sampling plans, analytical methodology, quality control, data reporting, etc. For example, a comparability question would be whether analysis based on different portions of fish are comparable (i.e., whole versus edible portions).

- Completeness is a measure of all information necessary for a valid scientific study. A useful way to evaluate completeness is to carefully compare project objectives with the proposed data acquisition and resulting potential "short falls" in needed information. Generally, it is not useful to try to measure this in quantitative terms for most water monitoring projects.

9. Sampling Procedures

For each environmental parameter or parameter group to be measured, a complete description of the sampling procedure must be documented. Included as vital elements in the sampling documentation should be: inclusion of specific sampling procedures (by reference to Standard Operating Procedures or by detailed descriptions of state-of-the-art methods, where used); flow

diagrams or tracking mechanisms to chart sampling operations; and descriptions of sampling devices, sampling containers, preservation techniques, sample holding times and sample identification forms.

10. Sample Tracking Procedures

Sample tracking procedures begin with the cleaning of the sample containers to be used, a written record of the laboratory's source and manner of preparation of all sample containers should be referenced. This should include the laboratory's quality control procedures for assuring that the "cleaned" containers are truly decontaminated.

A detailed description of how sample containers are handled (in both the field and laboratory) to prevent inadvertent contamination.

Each distinct operation in the sample analysis, calculation and reporting should be recorded to ensure that data are not lost, are properly identified, and required parameters are reported.

11. Calibration Procedures and Preventive Maintenance

The purpose of this section is to document, by describing in detail or referencing the appropriate SOP, methods which are utilized to assure that field and laboratory equipment are functioning optimally. The frequency of application of these methods should also be appropriately recorded.

Exhibits 11.1 and 11.2 are examples of checklists for field and laboratory equipment.

An equipment logbook is to be maintained in addition to the checklist. The equipment logbook should remain with the piece of equipment except when the equipment is sent out for repairs. The logbook should contain records of usage maintenance, calibration, and repairs.

Exhibit 11.1

Field Equipment Checklist Example

Automatic Sample	Task	Frequency
Battery	Clean and charge	After each sampling
Pump Tubing	Soak, scrub, rinse	After each sampling
Discharge Tube	Soak, scrub, rinse	After each sampling
Splash Shield	Scrub, rinse	After each sampling
Bottles	Clean, rinse, dry	After each sampling
Intake Nozzle	Disassemble, clean, rinse	After each sampling

Exhibit 11.2

Laboratory Equipment Checklist Example[a]

Absorption Spectrophotometer	Frequency	Identify Each Sample Number and Date
Calibrate against standard	Each nth determination	Standard number 5. 11/10/82

[a]Provide detail if not given in the analytical method.

12. Documentation, Data Reduction and Reporting

The purpose of this section is to describe documentation, data reduction, and reporting:

A. Documentation - There must be adequate documentation available with all data. This is necessary to help in fully interpreting the data as well as to protect it against legal and scientific challenges. Records must be legible, complete and properly organized. In some cases, they must be protected, using a document control system.

In the work/QA Project Plan, SOPs should be referenced and included which define the type of record to be maintained as well as indicating where and how records will be stored.

B. Data Reduction and Reporting - "Paper work" errors are commonly found in the calculations, reductions and transfer of data to various forms and reports and transmittal of data into data storage systems. Quality control procedures should be carefully designed to eliminate errors during these steps. Calculation procedures should be described, to the extent possible, in analytical SOPs. SOPs should be included in the Work/QA Project Plan which describe review and cross-check procedures for calculations. Also, the SOPs should completely cover the step-wise procedures for entering data onto various forms and into computer systems. In addition to handling data, procedures should cover routine data transfer and entry validation checks. Where data forms are used, they should be included in the SOPs.

13. Data Validation

Each program must establish technically sound and documented data validation criteria which will serve to accept/reject data in a uniform and consistent manner.

Data validation can be envisioned as a systematic procedure of reviewing a body of data against a set of established criteria to provide a specified level of assurance of its validity prior to its intended use.

Data validation is, of necessity, conducted "after the fact." It requires that the techniques utilized are applied to the body of the data in a systematic and uniform manner. The process of data validation must be close to the origin of the data, independent of the data production process, and objective in approach.

Criteria for data validation must include checks for internal consistency, checks for verification of laboratoary capability, etc. These criteria involve utilization of techniques such as interpretation of the results of: external performance evaluation audits; split sample analyses; duplicate sample analysis (field and laboratory); spiked addition recoveries; instrument calibrations; detection limits; intralaboratory comparisons; interlaboratory comparisons; tests for normality; tests for outliers; and data base entry checks.

14. Performance and System Audits

Performance and systems audits are an essential part of every quality control program. A performance audit independently collects measurement data using performance evaluation samples. A systems audit consists of a review of the total data production process which includes on-site reviews of a field and laboratory's operational systems and physical facilities for sampling, calibration and measurement protocols.

To the extent possible, these audits should be conducted by individuals who are not directly involved in the measurement process. Audits serve three purposes:

(1) to determine if a particular group has the capability to conduct the monitoring before the project is initiated;
(2) to verify that the QA Project Plan and associated SOPs are being implemented; and
(3) to detect and define problems so that immediate corrective action can begin.

A Work/QA Project Plan should specify who will conduct the audit, what protocol will be used, what the acceptance criteria will be and to whom the audit reports will go. Generally, the dates for conducting the audits should be listed unless it is decided to conduct these unannounced. Performance evaluation samples produced by EPA can be used as a type of performance audit. These samples can also be obtained from the National

Bureau of Standards, United States Geological Survey commercial sources or in-house sources. Generally, it should not be necessary to conduct these audits if the group being tested has successfully performed within the last 6 months for the particular parameters in question.

15. Corrective Action

A corrective action program, which must have the capability to discern errors or defects at any point in the project implementation process, is an essential management tool for both project coordination and Quality Assurance/Quality Control activities.

A plausible corrective action scheme must be designed to identify defects, tally defects, trace defects to their source, plan and implement measures to correct identified defects, maintain documentation of the results of the corrective process, and continue the process until each defect is eliminated.

Each organization must develop a corrective action protocol which is technically effective as well as administratively compatible.

16. Reports

Formal reports must be issued to inform appropriate management personnel as well as QMWG of progress in the execution of the work plan. The reports should include an assessment of the status of the project in relation to the proposed timetable. The reports should also address any results of ongoing

performance and systems audits, data quality assessments and significant quality assurance, problems with proposed corrective action procedures.

The final report shall be issued, consistent with the rationale for executing the Work/QA Project Plan. The report shall also include appropriate data quality assessment.

ATTACHMENT 1

E. Parameter Table

Parameter	Number of Samples	Sample Matrix	Analytical Method Reference*	Sample Preservation	Holding Time
Free cyanide	300	water	335.2	**	**
Total cyanide	300	water	335.2	**	**
Amenable cyanide	300	water	335.1	**	**
BOD	50	water	405.1	**	**
COD	50	water	410.4	**	**
TOC	50	water	415.1	**	**
NH_3-N	50	water	350.1	**	**
Chromium	50	water	#218	**	**
Free cyanide	25	sediment	335.2	**	**
Total cyanide	25	sediment	335.2	**	**
Amenable cyanide	25	sediment	335.1	**	**
Chromium	25	sediment	#218	**	**
Free cyanide	25	sediment leachate	335.2	**	**
Total cyanide	25	sediment leachate	335.2	**	**
Amenable cyanide	25	sediment leachate	335.1	**	**
Chromium	25	sediment leachate	#218	**	**

* - Sediment and leachate sample preparation documented in Laboratory Methods Manual.

** - As specified in procedure EPA Methods for Chemical Analysis of Water and Wastes.

ATTACHMENT 2

9. Schedule of Tasks and Products

	Oct	Nov	1981 Dec	1982 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct
1. Project request				X									
2. Project plan review									→|				
3. Project plan finalized										→|			
4. Field reconnaissance	X												
5. Sample collection											→|		
6. All lab. analysis completed and submitted to project officer											→|		
7. Data entry into STORET													→|
8. Interim project report											X	X	
9. Final project report													X

ATTACHMENT 3

TABLE I. MINIMUM DATA REQUIREMENTS

Parameter	Matrix	Anticipated Range µg/L	Minimum Discernible Change µg/L	Confidence Range µg/L	Desired Reporting Increment µg	Anticipated Frequency of Sample Delivery	Approximate Workload Anticipated
X	Water	5-15	1	±0.5	0.5	Y	Z

ATTACHMENT 4

TABLE II. METHOD CAPABILITY

Parameter	Matrix	Method	Range	Reporting Increment	Low Level-SD	Mid-Point SD	Confidence Range	Detection Limit (95%)	Maximum Capacity Per Week	Capacity Allocated to this Projec
X	Water	(Ref.)	1-200	1	2	3	±3	5	Y	Z

TABLE V. QUALITY MANAGEMENT WORK GROUP
QUALITY MANAGEMENT STRATEGY

1. QUALITY ASSURANCE PROCEDURES AND DOCUMENTATION a. Project b. Field c. Laboratory	1. PROJECT PERFORMANCE EVALUATION AND DATA COLLECTION a. Within Agency QA/QC - Field & Laboratory Controls b. Duplicates and spiked samples at some specified frequency	1. PERFORMANCE EVALUATION DATA ASSESSMENT a. Current control status	1. IMPACT OF QUALITY ASSURANCE PROGRAM ON PROJECT a. Quality Assurance Success Assessment
2. PROJECT COMBINED QUALITY ASSURANCE/ WORK PLAN	2. BETWEEN AGENCY/ PROJECT a. Regular split sample exchange (minimum of one per parameter, matrix and sampling run.		
3. DATA QUALITY OBJECTIVES a. Sensitivity (detection limit requirements. b. Accuracy requirements. c. Data reporting requirements (qualifying data zero vs. not detected, trace etc.)	3. SPECIAL FIELD SPLIT SAMPLE EVALUATION (to be implemented when problems are identified in item 2 above. 4. BETWEEN LABORATORY PERFORMANCE a. Performance evaluation concentrates b. Performance evaluation whole samples		

APPENDIX III

Concerns of the QMWG

DRAFT (March 21, 1986)

Concerns of QMWG

Introduction

As mentioned several time to MC and AIC at the outset, all in-house QA/QC procedures, analytical methodologies, field sampling protocols are to be documented and reveiwed before the field season so that potential non-compatability of data can be spotted early. Inter-laboratory PE(QC) studies should be designed and conducted at least 3 times with samples of several concentration levels before, during and close to the end of the field seasons.

Due to restraints in resources, time, PY's and institutional restraints of work groups, the above cannot be done. Similiarly, the expectation in Section D, page 4 of the final report is unrealistically ambitious.

Current and Future Problems

1. Insufficient lead time to prepare and conduct interlab studies.
2. Most W/QA Project Plans received so for are non specific to UGLCCS in the area of QA/QC, protocol and lacking documented analytical methodology.
3. Agencies use different field and lab procedure. Due to institutional and time restraints, nothing could be done if these generate non-compatable data.
4. Most projects start before W/QA Project Plans are reviewed.
5. Due to institutional restraints, the mechanism for QA management is not effective to deal with:

   a) implementation of QA/QC requirements and activities within each WG.

b) tardiness in providing the necessary QA/QA information and analytical methodologies for review.

c) tradiness in some members of QMWG in the review process.

6. In-house QA/QC activities and progress of WGs not made available to QMWG. It was suggested earlier, to have periodical QA/QC reports from each WGs such as on the results of field split samples, inter change samples,in-house checks, etc.

7. Activity B-4 is generally overlooked by other WGs.

8. Some recommendations made in 1985 by the QMWG to MC were not accepted or enforced thus reducing the effectiveness of the overall QA program.

9. Various institutional restraints and red tape in providing essential resource support to QMWG also slowdown the activites several months.

10. Enforcement of QA activities by MC and AIC can be strengthened.

11. Effectiveness of the overall QA program affected by the difficulties in obtaining information on:

    1) laboratories list (now compiled)

    2) well documented field and analytical methodologies (not yet available)

12. Insufficient information on what is needed to be compatible and to what degree.

13. Unclear on the criteria on acceptability of data for a particular project per type of parameter and substrate. The project leaders and the WG chairman can provide this.

14. Expectation of the QMWG are unrealistic in view of the institutional time restraints and lack of QA management protocols.

Current Status

Re: items in Section D, page 4 of "Final Report Outline"

1. Intended use of data

This topic should be a joint effort of all WG chairmen and project leaders as they know exactly what is the intended use of the data. The authors of the final report will edit the write up for coherence. It is ineffective and misleading for others, such as us, to intepret the intended use.

2. Measurement process

It is intrepreted as analytical procedures used by the laboratories. In the W/QA Project Plans received so far, little documentation on analytical methodologies is included. Sometimes there is no reference to the analytical methodologies at all. Sometimes some vague referral to outdated laboratory manuals. So far, in most cases, what exactly the analytical protocols used by other WGs to generate data are not known. As a last resort, potential UGLCCS laboratories were asked to supply analytical methodologies. Because QMWG is the "3rd party", this mechanism is not as efficient as the QMWG's earlier proposal, that each WG chairman submit documentation and performance characteristics (as outlined in W/QA project - Plan Guideline) be used by the individual WG.

3. Availability of resources.

Resources (PY) and time restraint and laboratory space limitation

only allows a VW approach. Section D is for a Cadillac approach.

4. Definition of QA/QC Protocols/SOPs?

There is no SOPs among all the agencies.

This section could be eliminated and a,b and c put under D.2.

Information on a,b and c needed to be provided by WG chairmen.

5. Interlaboratory replication/common QA/QC protocols.

Sample representativeness and completeness partly depend on the sampling design but mainly on knowledge of the system generally obtained from investigation. The statistical consultants review of W/QA project plans can help to some extent. The WG chairmen and project leaders should address these aspects on the system (geographical area) they study.

Interlaboratory PE (or QC) studies can address the question of comparability.

6. Field and laboratory procedures, etc.

The W/QA Project Plans were designed to contain field and laboratory procedures. So far, they are quite disjointed and not all W/QA Project Plans are in. Each chairman of the WG should be quite familiar with his own projects and should write up this to be integrated by the authors of this report. The MC needs to ensure implementation of all field and laboratory QA/QC as claimed by the WGs.

7. The QMWG will take care of the data from interlab PE(QC) studies in terms of data reduction reporting and validation but obviously cannot and should not, take care of data of other WG for the studies. Data reduction, reporting and validation are part of the in-house activities of each project within each WG.

8. One may consider that the titles in D Section could be revised, condensed and clarified. Also, the outlines can be difficult and time consuming to write and the product can look like a big compilation of US and Canadian field and laboratory methods and QA/QC protocols without serving any significant purpose.

Expected Product

The products expected from the QMWG are:

1. Individual interlaboratory PE(QC) studies.
2. Intergrated reports on interlab PE studies for each type of organic parameters for water, sediments and fish and inorganics in water. 5 or 6 reports expected. These reports provide statements on quality of data of the QC samples.
3. Interim short reports on problem labs identified by interlab studies.
4. Reports on review of W/QA Project Plans.
5. Comments on data of split field sample when available.

APPENDIX IV

Glossary of Terms

GLOSSARY OF TERMS

The quality of analytical results must be considered in terms of correct identity and recovery of the target analyte, and the precision and accuracy of measurement. Failure to control recovery and accuracy can seriously affect inter-project comparison of findings.

Recovery is a measure of the ability of the analyst to control all steps needed to cnvert the sample to a form suitable to the measurement process being used. These processes must be controlled to prevent samle contamination, minimize loss of the target constituent, remove interferences, etc., which would lead to bias between projects.

Precision is a measure of the analyst's ability to get the same result on repeated trials. Accuracy is a measure of the analysts ability to obtain and use standards properly in calibrating the instrumentation used to quantitate results. Good precision is not an indicator of accuracy.

Quality Management

Management activities undertaken to ensure that staff are informed of their responsibilities to establish and maintain the desired level of quality and to document the mechanism for achieving

this. Quality management balances conflicting needs and priorities and endorses internal and external audits of the system, procedures and levels of quality achieved.

Quality Assurance

Activities that define the way in which tasks are to be performed to ensure that the final product will meet a desired level of quality. Quality Assurance ensures that operatins and procedures requiring control are identified and that appropriate control protocols are defined and implemented.

Quality Planning

An exercise which ensures that resources are used wisely by defining project needs in advance and ensuring project feasibility.

Quality Control

Operational level activities to determine and verify the suitability of various components within a process and to identify and eliminate erroneous measurements, observations and materials. Included are equipment and procedural control.